worthy of being added to these descriptions, as it is also contained in the same collection :—

Glyciphila flavotincta.

It is very like *Glyciphila modesta*, G. R. G., of New Caledonia; but it is rather larger in all its proportions, and it has a prominent tinge of yellow on the back and beneath the body, which is not found on the bird referred to.

Length 6″, wings 3″ 3‴, bill 12‴, tarsi 10‴.

"Eyes black. Contents of stomach honey. Male and female."

Three specimens were obtained at Erromango Island.

XXXV.—*On Fertilization in Ferns.*

By Dr. Edward Strasburger*.

The author affirms that he is enabled, by a series of observations on the prothallia of *Pteris serrulata* and *Ceratopteris thalictroides*, to correct certain errors of previous observers as to the way in which fertilization is effected in Cryptogams, and considers that the results attained by him in these instances are calculated to throw a new light on the whole subject. He commences the account of his experiments by tracing the development of the antheridia, or cells producing the spermatozoids, from their earliest condition, and states that the growth of their lateral cells presents the first example of annular-cell formation by division in the vegetable kingdom—a fact brought to notice by Dr. L. Kny in a paper communicated to the Society of the Friends of Natural History in Berlin, in November 1868†. After detailing step by step the growth of the cells in an antheridium, Dr. Strasburger observes that the new twin cells, viz. the central cell and the annular lateral cells, are distinguished from ordinary cells by the difference of their contents, the inner one being stuffed with granular protoplasm, the outer ones containing, at first, an almost colourless sap, with a single, scarcely discernible nucleus, and a few scattered grains of chlorophyll. He then describes the formation of the cells producing the spermatozoids in the following manner :—

Pteris serrulata presents several forms of antheridia: in young prothallia they are commonly unicellular, in older ones

* From Pringsheim's 'Jahrbücher für wissenschaftliche Botanik,' vii. Band, 3tes Heft. Communicated by C. E. Broome, F.L.S. &c.

† "Ueber den Bau und die Entwicklung des Farm-Antheridiums." Berlin, 1869. (Ann. Nat. Hist. p. 233 of the present volume.)

frequently many-celled. In unicellular antheridia the whole space becomes the mother cell of the spermatozoids; in those consisting of many cells the central cell alone becomes the mother cell. By a series of partitions the mother cell is divided into numerous small cells, which are the special mother cells of the spermatozoids; each of these possesses a distinct nucleus; by mutual pressure they become at first polygonal; their arrangement then becomes confused, the nucleus disappears, giving place to a uniformly granular mass. A rose-coloured vacuole soon appears in this mass, the protoplasm gradually retreats towards the walls of its cell, the central vacuole becoming proportionally enlarged; small granules next appear suspended in the fluid contents, the protoplasm collected against the cell-walls divides itself into a spiral band, which, commencing from a single point, describes several coils around the central vacuole. During this process the special mother cells assume more and more a globose form, and separate themselves from each other, their walls gradually becoming more delicate. The lateral cells meanwhile are compressed by the increasing volume of the contents of the central ones, and the upper or crown cell is filled by the special mother cells. If the antheridium be now placed in water, the top cell is ruptured in a stellate manner by the expansive force of the contents, and the special mother cells make their escape through the opening. The annular lateral cells of the compound antheridia now become of use; for, as the special mother cells make their exit, the former increase in bulk, and force the remaining special mother cells out of the central cell. The spermatozoid commonly lies quiet for so long a time as the special mother cells require for opening; its coils are closely pressed one on another within the cell, and must exercise a certain elastic force on its walls. The softened membrane at last gives way, the spiral coil suddenly unfolds itself, and the spermatozoid moves rapidly away. The special mother cell now disappears. During its motion the spermatozoid turns rapidly on its axis; its body forms three or four coils, which become wider as they recede. The foremost narrow coils are beset with long cilia: on the last and widest coil a colourless vesicle is visible, containing numerous minute granules; this seems to be the vacuole before noticed in the contents of the special mother cell. The vesicle is adhesive; and the spermatozoid may be sometimes seen hanging on by it to foreign bodies, where it struggles to free itself, in failure of which, the hinder end of the spermatozoid produces itself into a long thread, which is eventually torn asunder. The vesicle swells out in water; and if the spermatozoid cannot get quit of it, it

becomes so large as to hamper its movements and prevent its advancing; such spermatozoids may be seen, when the period of their swarming is nearly over, sinking to the bottom, where the vesicle and finally the spermatozoid are absorbed.

Before proceeding to relate the behaviour of the spermatozoids, Dr. Strasburger thus describes the development of the archegonia:—

Certain cells on the underside of an old prothallium, just behind the indentation of the front margin, and where it has attained some thickness, become the mother cells of archegonia. One of these cells is first divided, in a direction parallel to the surface of the prothallium, into an inner and larger cell, which becomes the central cell of the archegonium, and an outer, rather smaller one, which, after repeated division, forms the neck of the archegonium; by subsequent divisions the mother cell acquires two or more layers of cells. The canal through the neck is formed by the retreat of its central layer of cells from their contact with each other, or by absorption, where a central layer exists. But previously to this a delicate spherical cell is formed around the nucleus of the central cell, which becomes the mother cell of the future plant. A mass of protoplasm is then collected around the nucleus of the central cell, the protoplasm is separated from the other contents of the central cell by a convex line of demarcation, and thus becomes an independent cell; but no membrane composed of cellulose is demonstrable. The cell formed within the central cell is not the germ-vesicle, but rather the canal-cell, as Pringsheim has shown in *Salvinia*. The remaining contents of the central cell constitute the future germ-sphere; in its midst, close beneath the canal-cell, there lies a large nucleus with a distinct nucleolus. After further divisions of the neck-cells, the canal-cell pushes itself between them, and carries them up with it; within this cell a number of nuclei may now be seen. The growth of the cells of the neck does not proceed equally on all sides, so that the neck is bent down, and its crown cell turned towards the prothallium. When the number of the neck-cells is complete, another series of divisions takes place in the cells surrounding the central cell; at the same time the nuclei of the canal-cells resolve themselves slowly into a number of little granules, and unite at length into a granular mass, which soon fills the whole canal. The lower neck-cells now enlarge, thereby diminishing that portion of the canal; and its granular contents are thus partially forced into the upper part, there forming a wedge-shaped mass, which connects itself by a frequently very slender thread with that occupying the central cell. If the archegonium be now brought into contact

with water, the contents of the canal swell visibly, and a number of vacuoles appear in the internal granular mass. The distention increases; and at the apex, where the wedge-shaped mass was collected, the pressure becomes considerable: the free space in the canal is thus enlarged, and at last the upper cells of the neck can no longer resist; they part at the angles of contact, and the mucus is ejected with considerable force. The opening of the canal of the neck occurs at two periods: at first the mucus, which is massed at the summit, is poured out, either at once or at short intervals; then a period of rest occurs, after which the mass collected in the central cell is ejected altogether. The mucus is voided with sufficient force to remove any foreign bodies that may lie before the mouth of the canal, and thus to clear its orifice. The granular inner mucus is thus deposited at some little distance from the mouth of the archegonium; the outer, highly refractive mucus, on the other hand, which lined the walls of the canal, diffuses itself in the water in lines radiating from its mouth. After this evacuation the naked germ-sphere remains in the central cell; it assumes a globose form; and a transparent spot may, under favourable circumstances, be seen at its summit just above the nucleus, which may be denominated the germ-spot. The germ-sphere is now ready for fertilization.

Dr. Strasburger has been able to follow this process in all its details. In *Pteris* the opening of the canal and the entrance of the spermatozoids can be readily seen; but *Ceratopteris* exhibits in the clearest manner the proceedings of these bodies within the central cell, owing to the transparency of its prothallium. After the canal was opened, the spermatozoids, which had previously passed by it with the same indifference that they exhibited towards other bodies, showed a remarkable behaviour. When they reached the mucus before the canal, their movements became slower; they were evidently detained there, and their motion stopped, by an opposing medium: several remained fast in the mucus; others succeeded in freeing ing themselves and hastened away. But generally the course of the spermatozoid was so directed by the mucus radiating from the mouth of the canal that it steered head foremost for that aperture. One is not to imagine, however, that there was any diffusing stream or whirlpool, seizing on the spermatozoid and drawing it towards the orifice; for small granules remained perfectly quiescent in that position. The movement of the spermatozoid within the mucus then became slower; it did not cease to revolve on its axis, but the mucus directed it to the canal; so that its operation there may be compared to the action of the stigmatic juice, or of the tela conductrix

which directs the pollen-tube in Phanerogams towards the germ-vesicle.

We have here a proof of the fallacy of Roze's notion that it is the caudal bladder of the spermatozoid which contains the fertilizing matter. The greater number of these bodies had already lost this appendage before they reached the archegonium; others, which retained it at that time, lost it in the mucus; but no one carried it with it into the archegonial cell. In *Ceratopteris*, on one occasion, six spermatozoids, which had just escaped from their antheridium, had entered into the central cell of the archegonium, after which their six bladders were visible in the mucus before the mouth of the canal. Having entered the canal, the coils of the spermatozoid separated themselves from each other; and if no impediment arose in its course, the spermatozoid soon arrived in the central cell. Here the coils were again drawn together, and its movements again became free. The first spermatozoid was soon followed by others: four or five were able to find room in the cell; they there moved rapidly about amongst each other; later arrivals remained fast in the canal. In *Pteris* the number was sometimes considerable; each new comer twisted itself in between those already arrived, so long as any movement was possible; at last it extended itself at full length. When the canal was already full, one of these bodies was seen to insert its foremost end between those previously arrived, and so on, till a long chain of them was formed extending outwards from the canal-mouth. In this chain a spermatozoid might be seen revolving on its axis; and sometimes one would free itself and hasten away; Dr. Strasburger has observed one hundred of these bodies in a single chain in *Pteris serrulata*; others might be seen still involved in the mucus half an hour after the first had reached the central cell.

From the facts above stated, Dr. Strasburger considers it undeniable that it is the mucus which acts upon the spermatozoids; and his opinion was confirmed by removing this substance from the mouth of the canal, by raising the covering glass or with a needle, when the spermatozoid either remained in the mucus, and perished there, or, if it succeeded in freeing itself, it never more found its way back to the canal-mouth. The first spermatozoid that gained the central cell, either at once, or after wandering about a short time, impinged with its foremost end on the transparent or germ-spot on the summit of the germ-sphere, and there remained fast; it then turned quickly on its axis, and sank with its point slowly into the germ-sphere; its movements became slower; they soon ceased entirely; it continued to pass out of sight within the germ-

sphere, and dissolved away in its mass till, at the expiration of three or four minutes, no more could be seen of it. This operation was only witnessed five times out of numerous experiments, and when a single spermatozoid alone had penetrated into the central cell, owing to the canal being occupied by adventitious matters. When several spermatozoids had reached the central cell, they moved about amongst each other, so that it was impossible to follow any individual. Sometimes two or three of these bodies remained with their hinder ends attached to the germ-spot; they turned quickly on their axis, pushing one another aside, till one gained the mastery, and was so far received that it covered up the germ-spot with its coils. The others were then repulsed, and moved about for some time, their motions ceasing at times, to be recommenced after short intervals; this may have lasted eight or ten minutes, when they all sank to rest, and remained motionless where they fell. In one case, when two spermatozoids had reached the central cell, the second approached after the first had occupied the germ-spot a minute and a half and its front coils had been received into the germ-sphere; the second could not then displace the other, but soon relinquished its hold on the germ-spot, and, after long roving about, lay on its side near the germ-sphere. After four minutes nothing more was seen of the first; and after thirty-five minutes the second was also lost sight of. The usual results of the fertilization followed in the growth and colouring of the embryo, and were very conspicuous after the lapse of a few days.

Dr. Strasburger concludes his account by observing that fertilization seemed to be effected in these instances by a single spermatozoid, and considers it probable that the procedure is similar in the other Cryptogams which produce these bodies. The chief point of interest in the above experiments (which the author appears to have carried further, and to have detailed with greater accuracy, than previous observers) consists in the means adopted by nature to conduct the spermatozoids to the scene of their operations, and in his reasonings on the nature of their movement, which has been sometimes supposed to be connected with molecular motion by those who have not observed it with sufficient care. It remains for future investigators to ascertain if the same facts can be traced in other Cryptogams.